EFFECT OF FLIGHT ACTIVITY ON LABORATORY RESPONSE OF THE SOUTHERN PINE BEETLE TO AN ATTRACTANT[1]

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ABSTRACT

Post-flight response of the southern pine beetle (*Dendroctonus frontalis* Zimmermann) to an attractant mixture (frontalin, transverbenol, and loblolly pine turpentine) was measured in the laboratory. Response of post-flight male and female beetles was greater than pre-flight control beetles. A greater proportion of post-flight males responded than post-flight females.

Key Words: Flight, *Dendroctonus frontalis*, pheromone, bark beetle

INTRODUCTION

Host selection by the southern pine beetle, *Dendroctonus frontalis* Zimmerman, begins with the emergence of female beetles, which are the first individuals to fly to uninfested trees. These females are thus referred to as pioneer beetles (Borden 1974). They release aggregating pheromones and initiate boring activity. Responding male and female beetles leave previously infested host trees and fly to the freshly-attacked tree to complete the colonization process (Vité and Francke 1976).

Several studies have been conducted on scolytid flight activity, including the influence of flight on olfactory response (Graham 1959; Gara and Vité 1962; Gara 1963; Atkins 1969; Rudinsky and Schneider 1969; Hughes and Pitman 1970; Bennett and Borden 1971; White and Franklin 1976; Gere

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1979). However, none of those studies dealt with the influence of flight on olfactory response in the southern pine beetle. The following study was carried out to determine if flight exercise effects response of the southern pine beetle to attractant chemicals.

METHODS AND MATERIALS

Infested loblolly pine bark was periodically gathered in East Texas from November 1979 through March 1980 and contained in the laboratory in an emergence chamber. Emerged beetles were collected daily, sexed twice, screened for the presence of all antennae and legs, and placed individually into gelatin capsules. All beetles were maintained under identical conditions of light, temperature, (X = 28 C) and humidity (X = 52% RH).

Beetles were individually attached to a flight mill board based on a design by H. A. Moeck (pers. comm.) (Fig. 1). The mill consisted of a fine wire, ca. 12 cm long, looped around a large-gauge hypodermic needle. Two separated gelatin capsules placed on both ends of the needle maintained an unobstructed vertical plane of rotation for the wire. The needle was inserted horizontally into a cork which rested on a 35 mm film canister. At one end of the wire a beetle was attached at the pronotum with Dap® tub and tile caulking. Counter weight was added on the opposite arm of the wire for balance.

Beetles were encouraged to fly by lightly spinning the wire for one or two revolutions, and were allowed to fly as long as 90 minutes. The flight durations was recorded, and the beetles failing to fly within 60 minutes were removed. Effect of flight duration was determined by comparing responses of beetles flow 1 - 30 minutes, 31 - 60 minutes and 61 - 90 minutes. Bennett and Borden (1971), with their work on *Trypodendron lineatum* (Oliver) and *D. pseudotsugae*, (Hopkins) found that flight activity of about 90 minutes may have affected behavior of the beetles by exerting an inhibitory influence on a chemotactic arrestment response.

Flown and non-flown (control) beetles were assayed for their response to the attractant mixture of frontalin, trans-verbenol, and loblolly pine turpentine in a 1:1:12 ratio using pentane as a solvent for dilution. All flown beetles were assayed within six hours after flying using the bioassay described by Payne *et al.* (1976). Beetles not placed on the flight mill were assayed as controls. Airflow in the system was 1 l/min., and the test chemical was eluted at 60 µg/min. For each assay one beetle was released on the center of a clean paper on the assay table and its behavior was observed. A positive response was recorded when the beetle walked to within 1 cm of the chemical source. Beetles were allowed up to five minutes to respond.

The data were analyzed using X^2 procedures.

RESULTS AND DISCUSSION

Significant differences were found between the flown and control southern pine beetles in their response to the attractant mixture (Table 1). Seventy-nine and fifty percent of the flown males and females, respectively, responded to the mixture as compared to only sixty-two and twenty-five percent of the controls.

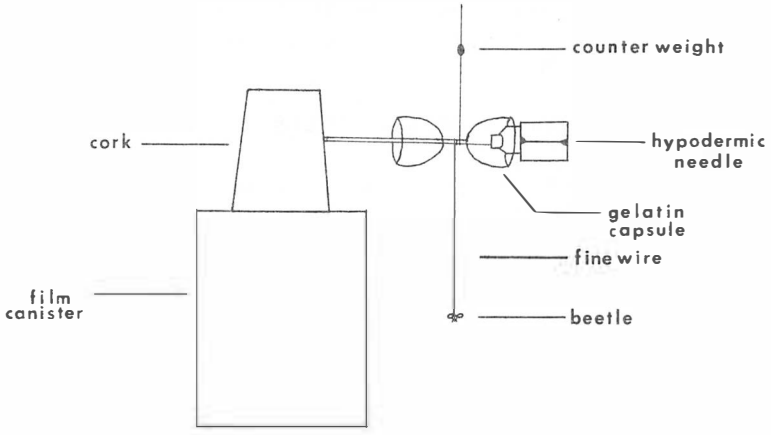

Fig. 1. – Schematic of flight mill (after H. A. Moeck personal communication).

A significant difference was also found between the responses of flown male and flown female beetles, with flown males exhibiting a greater response. This result was not surprising since non-flown males were more responsive to the attractant mixture than non-flown females in this study, as well as in a previous study (Payne *et al.* 1976). Similar differences in male and female response were found in field tests (Renwick and Vité 1969) and in electrophysiological experiments on antennal olfactory responsiveness (Dickens and Payne 1977).

The presence of greater response to attractant in males over females appears of adaptive significance to the species. Female southern pine beetles are the pioneering sex in the attack on host trees. Once on the tree, they release pheromone which attracts more males than females. As a result of this behavior, the probability is increased that females will be mated and the species propogated.

In field studies on a closely related species, *D. brevicomis* LeConte, Gara and Vité (1962) found that the beetles would respond immediately to sources of attraction soon after emergence. They concluded that flight exercise was not prerequisite to response since the flight times were less than a minute. The results from our study suggests a similar behavior of the southern pine beetle. Gara (1963) reached similar conclusions with his work on *Ips confusus* (LeConte) (=*I. paraconfusus* Lanier).

By comparison Bennett and Borden (1971) found that in flight mill studies *T. lineatum* and *D. pseudotsugae* required flight before they would respond to female frass as a source of attractant. Atkins (1969) had previously found flight effected response of *D. pseudotsugae* to its host. He related lipid content and host attraction in his work on *D. pseudotsugae.* He demonstrated that as lipid reserves were depleted during flight, the beetles became increasingly attracted to the host plant. He stated that behavioral change, flight exercise, age, and amount of stored fat appeared to be interrelated (Atkins 1966).

Table 1. – Percent response of flown and control *Dendroctonus frontalis* to an attractant in the laboratory.[1]

	RESPONSE %	NO RESPONSE %
FLOWN MALES (N = 97)	79	21
CONTROL MALES (N = 153)	62	38
FLOWN FEMALES (N = 82)	50	50
CONTROL FEMALES (N = 111)	25	75

[1] χ^2 analysis for flown males vs. control males P 0.001.
χ^2 analysis for flown females vs. control females P 0.001.
χ^2 analysis for flown males vs flown females P 0.001.
$\bar{X}$ flight times, 43 and 55 min. for males and females, respectively, were not significantly different.

Our results show that although flight exercise significantly increased attraction in laboratory assays, significant levels of attraction were elicited from non-flown beetles. Tests remain to be conducted to determine whether or not flight exercise influences the aggregation behavior of the southern pine beetle in the field and whether season influences the effect of flight exercise on olfactory response.

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LITERATURE CITED

Atkins, M. D. 1966. Laboratory studies on the behavior of the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins. Can. Entomol. 98: 953-91.

Atkins, M. D. 1969. Lipid loss with flight in the Douglas-fir beetle. Can. Entomol. 101 164-5.

Bennett, R. B. and J. H. Borden. 1971. Flight arrestment of tethered *Dendroctonus pseudotsugae* and *Trypodendron lineatum* (Coleoptera: Scolytidae) in response to olfactory stimuli. Ann. Entomol. Soc. Amer. 64: 1273-86.

Borden, J. H. 1974. Aggregation pheromones in the Scolytidae. p. 135-160. In: M. Birch (ed.), *Pheromones*. North Holland.

Dickens, J. C. and T. L. Payne. 1977. Bark beetle olfaction: pheromone receptor system in *Dendroctonus frontalis*. J. Insect Physiol. 23: 481-9.

Cara, R. L. 1963. Studies on the flight behavior of *Ips confusus* (Lec) (Coleoptera: Scolytidae) in response to attractive material. Contrib. Boyce Thompson Inst. 22: 51-66.

Gara, R. I. and J. P. Vité. 1962. Studies on the flight patterns of bark beetles

(Coleoptera: Scolytidae) in second growth ponderosa pine forests. Contrib. Boyce Thompson Inst. 21: 275-89.

Gere, S. F. 1979. Affects of weather on flight of the southern pine beetle *Dendroctonus frontalis* Zimm. (Coleoptera: Scolytidae). MS Thesis. Stephen F. Austin State University. Nacogdoches, Texas. 91 pp.

Graham, K. 1959. Release by flight exercise of a chemotropic response from photo-positive domination in a scolytid beetle. Nature 184: 283-4.

Hughes, P. R. and G. B. Pitman. 1970. Method for observing and recording flight of tethered beetles. Contrib. Boyce Thompson Inst. 24: 329-36.

Payne, T. L., E. R. Hart, L. J. Edson, F. A. McCarty, P. M. Billings, and J. E. Coster. 1976. Olfactometer for assay of behavioral chemicals for the southern pine beetle, *Dendroctonus frontalis* (Coleoptera: Scolytidae). J. Chem. Ecol. 2: 411-19.

Renwick, J. A. A. and J. P. Vité. 1969. Bark beetle attractants: mechanism of colonization by *Dendroctonus frontalis*. Nature 224: 1222-3.

Rudinsky, J. A. and I. Schneider. 1969. Effects of light intensity on the flight pattern of two *Gnathotrichus* (Coleoptera: Scolytidae) species. Can. Entomol. 101: 1248-55.

Vité, J. P. and W. Francke. 1976. The aggregation pheromones of bark beetles: progress and problems. Naturwis. 63: 550-5.

White, R. A., Jr. and R. T. Franklin. 1976. Activity of the southern pine beetle in response to temperature. J. Ga. Entomol. Soc. 11: 370-2.

J. Georgia Entomol. Soc. 17(4), Oct., 1982, 456-560